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Is lactate level beneficial in triage of non-traumatic emergencies?

Lactate in triage

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Abstract
Aim: In this study, we aimed to investigate if blood lactate levels, which have been proven to be effective in trauma triage, can serve as a guide in the triage of nontraumatic yellow and red zone (urgent and very urgent) zone patients.
Material and Methods: The relationship between venous blood lactate level and triage categories was investigated retrospectively in 1060 yellow and red zone patients who visited the emergency department between 19.02.2019 and 07.03.2019.
Results: The mean lactate level was significantly higher in patients categorized as red (very urgent) compared to patients categorized as yellow (urgent) (3.04±2.32 vs.1.93±1.08 mmol/L) ($p<0.05$, $p=0.001$). A lactate level >2 mmol/L could distinguish between red and yellow categories with a sensitivity of 64.15% and a specificity of 68.74% ($p<0.05$) respectively.
Discussion: Although the lactate level in the red zone is significantly higher than in the yellow zone, we do not consider it appropriate to use this parameter on non-traumatic triage decisions due to its low sensitivity and specificity.

Keywords
Emergency Medicine, Lactate, Triage

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Introduction

Triage is utilized worldwide to determine patient urgency at the scene or in the hospital setting in order to distinguish urgent and non-urgent patients who can wait for treatment in intensive emergency service. In the triage systems that are based on the patients' vital signs and brief history, cases of under- or over-triage are still noticeable. In order to minimize these cases, new simple diagnostic methods that can be administered at the bedside are being researched [1]. As an adjunct to the non-invasive monitoring performed in triage, markers of hypoperfusion and latent shock, which depict the cellular products of anaerobic metabolism and can be easily administered, seem to be suitable for this purpose.

Lactate is a tissue perfusion marker affected by both macro- and micro-circulation [2]. It provides information about global circulation, regardless of age and gender. In numerous studies, infection, trauma, sepsis, gastrointestinal bleeding, myocardial infarction, and increased postoperative lactate levels have been associated with increased hospitalization rate, morbidity, and mortality [3-7].

In this study, we aimed to investigate whether blood lactate level, which has been shown to be effective in trauma triage, can be a guide in the triage of non-traumatic yellow and red zone (urgent and very urgent) zone patients.

Material and Methods

Research Design, Population and Setting

The retrospective cross-sectional study was conducted by the Emergency Department of Health Sciences University, Bozyaka Research and Training Hospital. The emergency department serves an average of 95 000 patients per year in the province of Izmir, which has approximately 4.5 million population. The hospital is a large research and training center and serves all medicine, trauma, and surgical patient groups.

Emergency triage is conducted according to the triage scale devised by the Ministry of Health, which is similar to the START (Simple Triage and Rapid Treatment) Triage and consists of three categories: green (non urgent), yellow (urgent), and red (very urgent). Triage is performed by trained nurses and emergency medicine technicians.

Study Protocol

After obtaining the ethical approval, a total of 1060 patients were included in the study between the period 19.02.2019 and 07.03.2019. Patient data were obtained retrospectively from the hospital information management system. Demographic and clinical characteristics including age, gender, triage category, main symptom, final diagnosis, and clinical outcome (discharge, hospital admission, intensive care admission, death) were evaluated by an emergency specialist who was blinded to patients' lactate levels. Cases of over-and under-triage were determined and corrected according to the START Triage. Discharge diagnoses were categorized and documented according to medical fields. Venous blood lactate levels were listed by an emergency specialist blinded to the diagnoses and triage categories of the patients.

Discharge diagnoses were as follows:

1. Infectious diseases
2. Neurological diseases
3. Surgical emergencies
4. Cardiopulmonary diseases
5. Internal diseases (organ dysfunction, metabolic disorders)
6. Others (otorhinolaryngological diseases/peripheral vertigo, complicated upper respiratory tract infections, allergy, nonspecific abdominal pain, drug use, burns, decompression sickness, carbon monoxide poisoning, intoxication, hypothermia, vascular emergencies).

The inclusion criteria were as follows:

1. Age over 18 years
2. Emergency department admission
3. Prior venous blood gas analysis
4. A triage category of yellow or red

The exclusion criteria were as follows:

1. Pediatric patients (<16 years)
2. Pregnant patients
3. Patients presenting with psychiatric symptoms
5. Trauma patients
6. A triage category of green
7. Recent alcohol consumption
8. Patients who refused treatment and left the emergency department voluntarily
9. Death
10. Patients who had seizures after arrival

Blood collection and measurement of lactate levels

Venous blood gas samples that were obtained by emergency department nurses in the yellow and red areas of the emergency room following vascular access were transferred to a blood gas syringe containing dry lithium heparin and transported to the laboratory using the pneumatic system.

Blood gas analysis was performed using ABL 800 FLEX with commercially available kits (Radiometer Medical APS, 2700 Bronshoj, Denmark). The intra- and inter-assay coefficients of variation (CVs) of all tests were below 10%, as mentioned in their kit inserts. The Radiometer ABL800 FLEX is a point-of-care blood gas analyzer requiring 1.5 ml of whole blood and takes 2 minutes to run a sample.

Statistical analysis

Data were analyzed using SPPS for Windows version 25 (Armonk, NY: IBM Corp.). Descriptives were expressed as mean, standard deviation (SD), frequencies (n), percentiles, median, minimum, and maximum for the categorical and continuous variables as appropriate. Homogeneity of variances, which is one of the prerequisites of parametric tests, was assessed by using Levene's test. The normal distribution of the data was determined by using Shapiro-Wilk test. Parametric data were compared using Student's t-test and non-parametric data were compared using the Mann-Whitney U test. Three or more groups were compared using One-way ANOVA followed by post hoc Tukey's HSD test for parametric data and using the Kruskal-Wallis test followed by post hoc Bonferroni-Dunn test. The performance of a test was defined by the test's diagnostic adequacy or its capacity to correctly classify cases into subgroups (e.g. healthy vs. patient). Cut-off values of patients and healthy individuals were evaluated on the basis of measurement parameters using a Receiver Operating Characteristic (ROC) curve with the Area Under the ROC Curve (AUC) value and Sensitivity, and Specificity values. A p- value of

<0.05 or <0.01 was considered significant as appropriate. This study was approved by the Ethics Committee of University of Health Sciences Izmir Bozyaka Education and Research Hospital (Date: 2018-07-26, No: 03).

Ethical Approval

Ethics Committee approval for the study was obtained.

Results

Of all, 353 (33.3%) patients were categorized as red and 707 (66.7%) as yellow (Table-1).

Table-1 presents categorical and continuous variables of the patients.

A significant difference was found between lactate level and triage categories (p<0.05). Moreover, mean lactate level was higher in individuals in the red category compared to those in the yellow category (p<0.05), this presents a comparison of triage categories with regard to lactate level (Table-2).

A significant difference was observed between lactate levels and gender, whereby it was significantly higher in men compared to women (p<0.004) (Table-2).

A significant difference was found between lactate levels and clinical outcome (p<0.05). Although no significant difference was observed between the discharged and hospitalized patients with regard to lactate level, a significant difference was found between non-surviving patients and those admitted to intensive care. Non-surviving patients had the highest lactate levels (Table-2). There is no significance between the variables with the same letter.

A significant difference was observed between lactate levels and discharge diagnoses (p<0.05). Moreover, the difference between "other diseases" and neurological and cardiopulmonary diseases was statistically significant (p<0.05) with "other

Table 1. Categorical and Continuous variables

		N	%
Gender	Female	537	50.7
	Male	523	49.3
Triage category	Red	353	33.3
	Yellow	707	66.7
Clinical outcome	Death	4	0.4
	Discharged	663	62.5
	Admitted	250	23.6
	Admitted to ICU	143	13.5
Discharge diagnosis	Infections	126	11.9
	Neurological diseases	135	12.7
	Surgical emergencies	76	7.2
	Cardiopulmonary diseases	341	32.2
	Internal organ dysfunctions	177	16.7
	Other diseases	205	19.3
	Minimum-Maximum	**Mean**	**SD**
Age (years) (n=1060)	18.00-95.00	61.868	18.060
Lactate level (mmol/L) (n=1060)	0.60-21.00	2.299	1.6889

ICU: Intensive care unit, SD: Standard deviation

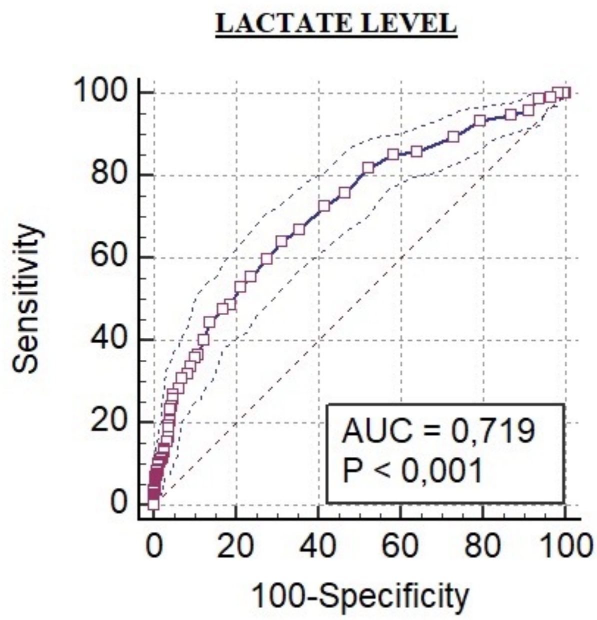

Figure 1. Predictive value of lactate level in the differentiation of the red and yellow categories.

Table 2. Comparison of triage categories, clinical outcomes, discharge diagnoses with lactate levels and Gender-based comparison of lactate levels.

	Red n=353			Yellow n=707		Test statistic		p
Lactate level (mmol/L)	3.04±2,32			1.93±1,08		-11.505		0.001€*
	Female n=537			Male n=523		Test statistic		p
Lactate level (mmol/L)	2.16±1,52			2.44±2,44		-2.739		0.006€*
	Death n=4	Discharge n=663	Admitted n=250	Admitted to ICU n=143		Test statistic		p
Lactate level (mmol/L)	9.03±8.52[a]	2.05±1.26[b]	2.29±1.47[b]	3.30±2.44[c]		86.907		0.001ψ*
	Infections n=126	Neurological diseases n=135	Surgical emergencies n=76	Cardiopulmonary diseases n=341	Internal organ dysfunction n=177	Other diseases n=205	Test statistic	p
Lactate level (mmol/L)	2.35±1.94[ab]	2.72±2.198[b]	1.98±0.92[ab]	2.32±1.29[b]	2.44±2.27[ab]	1.94±1.22[ac]	29.375	0.001ψ*

*p<0.05, ¥Independent samples t-test (Student's t-test), € Mann-Whitney U test, Δ One-way ANOVA, ψ Kruskal-Wallis test

Table 3. Predictive value of lactate level in the differentiation of red and yellow categories

	AUC	p	Criterion	Sensitivity	95% CI	Specificity	95% CI	+LR	95% CI	-LR	95% CI
Lactate level (mmol/L)	0.719	<0.0001	>2	64.15	58.9 - 69.1	68.74	65.2 - 72.1	2.May	1.8 - 2.3	0.52	0.5 - 0.6

AUC: Area Under the ROC curve, CI: Confidence interval, LR: Likelihood ratio

diseases" having the lowest mean lactate level (Table-2).
The ROC analysis indicated that a lactate level >2 mmol/L was good enough to distinguish between red and yellow categories with a sensitivity of 64.15% and a specificity of 68.74% ($p<0.05$) respectively (Table-3 and Figure-1).

Discussion

Lactate level is a laboratory parameter that has long been used in clinical medicine to evaluate disease severity or response to interventions [7]. Moreover, in clinical practice, blood lactate level is used as a marker of tissue hypoxia [8].

In our study, the mean lactate level was significantly higher in patients categorized as red (very urgent) than in ones categorized as yellow (urgent) (3.04±2.32 vs.1.93±1.08 mmol/L) ($p<0.05$, $p=0.001$). Additionally, the ROC analysis indicated that a lactate level of >2 mmol/L was able to distinguish between red and yellow categories with a sensitivity of 64.15% and a specificity of 68.74% ($p<0.05$). In a 2016 study, Fukumoto et al. investigated the relationship between lactate level and the triage categories in the START and the Canadian Triage and Acuity Scale (CTAS) scales using a portable lactate device and found a significant correlation between the lactate level and the START and CTAS categories, whereby the highest mean lactate level was observed in the black category (106±44 mg/dl), followed by red (47±39 mg/dl), yellow (20±13 mg/dl), and green (16±11 mg/dl), respectively ($p<0.0001$) [9]. Similarly, in our study, the mean lactate level was significantly higher in the red category compared to the yellow category ($p=0.001$). However, the study by Fukumato et al. was retrospective and the efficiency and accountability of portable lactate device in decision-making remain unknown, while in our study, there was no possibility of such bias since the triaging of patients was performed by the healthcare personnel who were blinded to patients' lactate levels.

In our study, a significant relationship was found between lactate level and clinical outcome ($p<0.05$). Although no significant difference was observed between the discharged and hospitalized patients with regard to lactate level ($p>0.05$), a significant difference was found between non-surviving patients (9.03±8.52 mmol/L) and those admitted to intensive care (3.30±2.44 mmol/L). Moreover, non surviving patients had the highest lactate levels. These findings are consistent with the literature [2,6,10-11] and indicate to the clinicians the importance of lactate levels in predicting clinical outcome and also implicate that although lactate level could not predict discharge or hospitalization, it seems to be effective in predicting mortality and the requirement of intensive care.

In our study, a significant difference was found between lactate level and discharge diagnoses ($p<0.05$). Moreover, the difference between "other diseases" and neurological and cardiopulmonary diseases was statistically significant ($p<0.05$). Additionally, the lowest mean lactate level was in the "other diseases" category, which included complicated upper respiratory tract infections, allergy, nonspecific abdominal pain, drug use, burns, decompression sickness, carbon monoxide poisoning, intoxication, hypothermia, vascular emergencies, and otorhinolaryngological diseases/peripheral vertigo, which were relatively less prevalent. We consider that the low lactate level in the "other diseases" category did not lead to a hypoxic microcirculation due to the high number of local diseases in this category.

In the comparison of lactate levels and genders in our study, a significant relationship was found between the two parameters. Of note, the mean lactate level was significantly higher in men compared to women ($p=0.006$). In an exercise study, Zhang et al. evaluated healthy young subjects and found no significant difference between genders with regard to plasma lactate levels ($p=0.39$) [12]. Theoretically, the findings in our study can be explained by the fact that males have less adipose tissue, a higher metabolic rate, and a greater muscle mass. In a confirmatory manner, although lactate is produced at varying degrees in all cells, the highest lactate production occurs in skeletal muscles [7]. In contrast, Lat et al. evaluated critical disease and gender-based differences in intensive care regardless of muscle mass and reported that sex hormones varied depending on the hormone cycle and disease state and also affected the course of critical diseases [13]. Additionally, the higher lactate levels in males could also be explained by the fact that female mitochondria produce less reactive oxygen species and preferably use more lipids for bioenergetics due to their higher oxidative capacity [14].

Based on our findings, we also suggest that, like Fukumoto [9],blood lactate level is higher in the red zone (very urgent) triage than in the yellow zone (urgent) triage in the emergency room. However, sensitivity, specificity, +LR, -LR values are not sufficient for lactate levels to be ideal diagnostic tests in triage for non-traumatic emergencies.

Limitations

Our study had several limitations. Firstly, it was a single-center study and no distinction was made between Type-A and Type-B hyperlactatemia during the evaluation of lactate levels. Secondly, tourniquet application is routinely performed worldwide while obtaining venous samples. Although prolonged tourniquet application may be effective in the accumulation of peripheral lactate, it was not possible to measure or standardize the time from tourniquet application to blood sample collection due to the retrospective nature of the study. Additionally though venous blood gas samples were transported to the laboratory through the pneumatic system shortly after blood collection in the emergency room, the time from blood collection to the insertion of the samples into the machine could not be measured accurately due to the retrospective nature of the study. Finally, an important limitation of our study was that this was a retrospective study and had an inclusion bias since only patients with complete clinical records were included.

Conclusion

Blood lactate level, which had a sensitivity of 64.15% and a specificity of 68.74% at a cut-off value of 2 mmol/L, can be used in triage in situations where the distinction between urgent and very urgent cases can not be made in order to correct the triage category of the patients and decide on the ideal treatment and transplantation even at the same triage level and to avoid under-triaging.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some *of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.*

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Conflict of Interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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